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School house heating and the Indiana law

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STATE BOARD OF ACCOUNTS

REPORT OF

SCHOOL HOUSE HEATING AND VENTILATING AND RULES ON PUBLIC BUILDING CONTRACTS

GILBERT H. HENDREN
State Examiner

1917

School House Heating and the Indiana Law

A Report Submitted to Gilbert H. Hendren, State Examiner, State Board of Accounts of Indiana, by C. B. Veal, School of Mechanical Engineering, Purdue University, and by the Department of Inspection and Supervision of Public Offices

To the Governor

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SCHOOL HOUSE HEATING AND VENTILATING AND RULES ON PUBLIC BUILDING CONTRACTS

INDIANA REFORMATORY PRINT, 1917

School House Heating and Ventilating in Indiana.

A diversity of opinion has existed for several years with respect to the relative merits of the various systems of heating and the ventilation of public school buildings and their compliance with the sanitary school house law of Indiana. The controversy between manufacturers of heating and ventilating systems and between contractors is renewed practically every time bids are received by township trustees and school boards and has frequently resulted in the elimination of meritorious systems, on the theory that such systems do not comply with the sanitary school house law. This practice restricts competition, fosters monopoly and, in many instances, results in contracts being awarded upon bids that are not the lowest submitted. It encourages collusion, conspiracy and extortion. Arguments made by manufacturers and contractors often confuse officials who are not experienced in heating and ventilating, and contracts are frequently secured for inferior heating systems at exorbitant prices through gross misrepresentation. It would be difficult to estimate the loss sustained by the taxpayers of the state through this corrupt practice.

The object of this department in making an investigation of this important matter was to find the system of heating and ventilating that will meet the requirements of the law, best conserve the public funds and encourage legitimate competition. It was our opinion that this question could be solved only by a searching investigation by expert heating and ventilating engineers who were in no way connected with the manufacture of heating and ventilating apparatus, or interested, directly or indirectly, in the heating business.

We presented the proposition to Professor Gilbert A. Young, head of the school of mechanical engineering of Purdue University, who referred the matter to Professor C. B. Veal, of the school of mechanical engineering of that institution. Professor Veal's investigation and the tests of existing systems were on the basis of the provisions of the sanitary school house law of Indiana, namely: heating, ventilating, humidity, initial cost, durability, up-keep, safety, operating cost and cleanliness. During the investigation, Professor Veal consulted those in charge of the engineering department in some of the largest universities of the United States and gave due consideration to their suggestions. He spent many months in making various tests and in the compilation of his report, which is regarded as the most complete of its kind published in the United States. Its practical use by township, school and other public officials who have charge of the construction of public buildings, including the installation of heating, ventilating and plumbing equipment, will effect a large saving to the taxpayers of Indiana, estimated by expert engineers at more than one hundred thousand dollars annually.

It is the desire of this department to encourage legitimate competition and to require that contractors comply with the provisions of the sanitary school house law, and with the rules and regulations of the State Board of Health as authorized by the Indiana statutes.

School House Heating and Ventilating and the Indiana Law.

I. Introduction.

In this report no attempt will be made to formulate definite specifications and rules for procedure in school house heating and ventilating. Attention will rather be directed to an analysis of the existing situation leading to certain recommendations which, if approved, may form the basis for regulating measures.

Any study of the present question logically divides itself into three considerations, the *available methods*, the *law* and the *demand*. Before a selection of heating methods can be made there must be a clear understanding of the principles of operation and relative adaptability of existing systems to school house heating. Under the *second* consideration, interpretion must be placed upon the provisions of the existing law, and classification made of available systems in accordance with their qualifications to compete under the law, i, e., "What does the law specify?" and "To what extent can the various systems qualify under the law?"

Under the third head two parallel questions should be considered: "What is demanded in the heating and ventilation of school houses?" and "Which systems will best satisfy these demands?"

II. Existing Systems.

A. Classification.

1. Heating Medium.

Heating systems may be broadly classified, according to the heat carrying medium employed, as hot air, hot water and steam.

2. Method of Circulation.

On the basis of the method employed to secure circulation, further division can be made into two classes; those using natural or gravity circulation, and those using forced circulation.

3. Position of Radiation.

Hot water and steam systems are also familiarly classed as *direct, indirect* or *direct-indirect,* according to the position and manner of using radiators.

a. Direct.

In *direct* heating the heating surfaces are placed in the space to be heated (obviously, stoves as well as steam and hot water radiators would be in this class), and no provision is made for ventilation, in the sense of admitting and heating outside air.

b. Indirect.

In *indirect* heating systems the heating surfaces are located in the basement or in some portion of the building outside the room to be heated, and air passing over these radiating surfaces acts as a medium to carry the heat through suitable ducts into the room. The air in such a system may receive its heat directly from the heating surface of a furnace or from radiators which are in turn heated by circulation of hot water or steam, and may be re-circulated from the building or admitted from outside.

c. Direct-Indirect.

Where the radiating surface is set within the room to be heated, as in the direct system, but arranged with ducts and openings in such a manner that air is drawn from the outside, heated and diffused into the room, the system is known as *direct-indirect.*

B. Description and Qualifications of the Various Systems.

1. Stoves.

The space occupied, attendance required, accompanying

dirt, and unsightly appearance of stoves are common arguments against their use in school rooms. The difficulty in securing equal diffusion of heat throughout the room, particularly along the floor or in the portion of a room exposed to heavy winds, and the serious objection, that in its plain, ordinary form it does not furnish ventilation, constitute almost equally evident objections to its use. With the modern equipment available the stove in its simplest form should not be tolerated in even the smallest one-room school building.

However, the market affords at a moderate price a number of designs in jacketed stoves or heaters which, when properly installed, comply with the essential intent of the present law. These "heaters" are really hot air furnaces set in the room instead of in the basement. They provide for the admission of outside air, either above or below the floor, release the heated air at sufficient height for proper diffusion, and can be operated in connection with aspirating foul air vents. They represent a type of direct-indirect system and, in many respects, in ventilating will have the advantages and disadvantages common to steam radiators of this type. When of sufficient size and correct proportions to permit the required number of changes of air per hour and still maintain satisfactory humidity and temperature without delivering overheated air they can be regarded as meeting the demand for small one-story, one or two-room buildings without basement.

2. Hot-Air Furnace Systems.

a. Natural Gravity Circulation.

The conventional hot-air furnace is little more than a specially designed stove surrounded by a casing and usually installed in the basement of the building to be heated. The air which serves as a heat carrying medium is taken either from the building itself or from the outside through ducts, and by means of the casing is made to pass directly over the heated surface of the stove or furnace. This air is expanded by heat and, being lighter than the surrounding atmosphere, rises through suitable flues to the various rooms to be heated.

Although it may be regarded as the most common method

of small residence heating today, as compared with other systems providing ventilation, its only advantage for school house heating lies in its low first cost. Its disadvantages are those common to the system, in residences or wherever installed, the principle of these lying in the fact that by this means it is very difficult to heat any portion of a building while that particular portion is directly exposed to a strong wind. Since the circulation of air is dependent entirely upon the difference in weight of equal volumes of hot and cold air, which at best is extremely small, the feeble circulating force available is easily overcome, on a windy day, by having air driven into the room on the windy side through window cracks and other leaks, thus creating a greater force tending to drive the hot air back down the pipes and depriving such rooms of heat supply at a time when it is most needed. Another serious objection to the hot-air furnace system is that the ducts are liable to become unsanitary through the collection of dust, and any cracks or leaks in the furnace permit the absorption or entrainment of noxious gases and soot by the incoming air, thus impairing, rather than improving, ventilation. Since the comparatively weak force impelling the air vertically is totally ineffective in a horizontal direction, it is evident that this sytems would not be suitable for large buildings, requiring long horizontal runs of pipe even though the loss of heat from the air could be effectually and economically prevented by insulation. For best service the furnace should be centrally located, and, with the inconvenience of its pipes, occupies more basement space than other systems.

Such a system cannot be recommended for school house heating except for buildings with not more than four rooms, where economy in first cost is absolutely essential, and then only when the utmost precaution is taken in the design and construction so as to comply with the intent of the law and the requirements of uniform heat and good ventilation.

b. Forced Circulation.

In hot air systems with forced circulation, i. e., a fan furnace system, a fan or blower is used for the purpose of forcing air past the heating surface of the furnace and on through hot air ducts into the rooms to be heated.

With increased initial, operating and maintenance costs this system will be subject to the same disadvantages as the gravity hot air furnace, except for positive circulation of the air to all parts of the building with less regard for the disturbing influence of outside winds. Although not an inherent fault of the system, the type of fan employed in its installation has all too frequently been inefficient and wholly unsuited to the economical propulsion of air under the required conditions of pressure, thus further increasing the cost of operation.

The impact under pressure of the cold air from out of doors against the frequently almost red hot fire-surfaces of the furnace is quite likely to develop cracks and leaks through strains produced by sudden cooling or unequal expansion of the metal, rendering this type of equipment more objectionable than a gravity plant by way of supplying coal gas and the products of combustion along with the supposedly "fresh" air. Evidently the fire hazard of such plants is very great and it is a matter of record that serious fires in public schools have so frequently been traced directly to furnace systems as to render the selection of such a system unwise from the standpoint of common safety. Furthermore, the temperature of the furnace is sometimes very high, and reducing the supply of air at any time tends to increase the furnace temperature, since the air supplies a cooling effect. Such a reduction in the supply of outside air will naturally increase the outgoing temperature of that which is supplied, thus resulting in excessively high temperatures of air entering class rooms. Temperatures as high as 275 degrees Fahr. have been observed by one of the best authorities. Such a temperature is dangerous to the structure of the building and, furthermore, very materially increases the fire hazard. It is unnecessary to call attention to the probable withering dryness of this air, or its harmful, if not positively painful, effect upon pupils subjected to its draught. With even normal temperatures of operation for a fan-blast system it will be found extremely difficult to consistently comply with any proper requirement in humidity, unless elaborate and expensive equipment be installed.

It may thus be seen that hand regulation of temperature and humidity may prove exceedingly troublesome;

any attempt to secure automatic temperature and humidity control is sure to prove an expense incommensurate with type of plant, and probably equally unsuccessful, unless made the subject of continuous care by a highly paid expert.

The erection of such a plant is particularly inadvisable where electric current is not available for driving the fan. Inasmuch as no steam is generated in the plant an internal combustion engine,—of a size and type expensive, noisy and uncertain in operation,—represents the only available motive power in such cases. The necessity of having gasoline fuel stored in or about the building constitutes, within itself, an added danger.

Although it is possible to find individual instances where the cost of operation of a fan furnace system has been less than that of a similar steam system, the consensus of opinion, from such records as are available, is that steam or "fan-coil" systems are less expensive to run, while without exception a direct-indirect steam system can be operated more cheaply. Light weight and poor construction of parts of the usual fan-furnace system, together with the development of cracks through great unevenness of temperature, lead to numerous and expensive repairs, often bringing the cost of maintenance above that of any normal allowance for depreciation. Whatever may be the advantage of the fan-furnace system it has been the almost universal experience that where such equipment has been installed it has been removed and replaced by some sort of steam system within a period of ten years, because of unsatisfactory service.

Although such systems may apparently comply with the letter of the law, it is not likely that their operation will fulfill the intent of any thorough-going sanitary or heating regulation. If this system is to be installed it should be with the best modern type of plate, or preferably multi-vane fan; it should have a furnace of ample and properly proportioned grate and heating surface for this particular work; and no contract should be let for such a system in any building without the approval of a competent and disinterested heating and ventilating engineer, and the health authorities.

3. Hot Water Systems.

While the low temperature of radiators, leading to greater transfer of heat through convection than through radiation, and consequently a more natural quality of heat, appears to commend hot water heating for direct radiation in school rooms; on the other hand, its high first cost, even with gravity circulation, lack of positiveness in circulation without pumps, large radiating surface, particularly with indirect arrangement, slowness in "heating up" and liability to breakage in radiators through freezing make hot water unsuitable as a heating medium for school houses, under most circumstacnes.

Without provision for ventilation in heating, it is quite possible in mild weather to run a hot water system with a very low fire, thus resulting in economy of operation, and securing a reduction in the coal bill which tends to offset the extra first cost of the installation; but during operation at full capacity the cost of fuel probably will be no less than for steam. This latter consideration will apply particularly with an indirect or direct-indirect system and there is little doubt but that the same money, if spent in installing a modern vapor-vacuum steam equipment, would result in just as low total cost per season.

4. Steam Systems.

Heating by steam is made dependable and uniform in operation through positive circulation, without mechanical devices to force it, and in this respect is unquestionably superior to either hot air or hot water. When properly fitted and piped every radiator should be kept hot without trouble. The radiators and piping are smaller than for hot water and there is no danger of freezing even with indirect or direct-indirect radiators.

For heating small and medium sized buildings there have recently come into extensive use various so-called *atmospheric* and *vapor* systems. These are all of a patented character —and as such need not be minutely described here—designed to make use of the principle that water will vaporize, or turn into steam, at a lower temperature if under a partial vacuum. In this respect the vapor systems differ from the vacuum systems employed in large public and office buildings only in the method of producing, and the amount of vacuum carried. The conventional vacuum system employs a pump or other power driven apparatus to produce the vacuum. As it would

not be economical to install an elaborate, motor driven apparatus in a rural or small school building several sufficient, positive and less expensive methods of producing a partial vacuum are offered by various companies. As in the case of *vapor* and *vacuum* systems the distinction between *atmospheric* and *vapor* systems is more one of degree than of kind. As the name indicates the atmospheric systems operate at, or slightly below, the pressure of the atmosphere.

In a flexible type of vapor system the degree of vacuum can be increased in mild weather, thus permitting practically as low fire as with a hot water system. By varying the amount of vacuum the temperature of the vapor or steam in the radiator can be graduated as with hot water, but with this decided advantage: during cold weather the steam can be put under pressure, oparating as a plain pressure system, thus requiring no larger pipes and radiators than a normal steam installation. Moreover, the expansion tank of the hot water system is eliminated; air valves are replaced by vapor or vacuum traps at the radiator outlets; and a return pipe to the vacuum-producing apparatus insures good circulation, and makes the process of "heating up" even more rapid than with low pressure steam. At the same time it avoids the attention, leaks and unpleasant odors associated with most air valves. In some of these systems the radiators are equipped with special inlet valves designed to permit easy hand modulation or control of the amount of steam admitted to the radiator, according to demand, thus effecting economy in the use of steam and reducing the pressure in the return pipes. There is no danger of injury where a radiator is exposed to freezing, and, in general, it may be said that, to a remarkable degree, these systems secure the advantages of both hot water and low pressure steam without the disadvantages of either.

Such systems do, however, have disadvantages peculiar to themselves. Primerily, objection to their use is based on liability of trouble arising from complications introduced in connection with the vacuum producing apparatus. Although more economical in design and equally efficient in operation, the prices of the patented specialties bring the first cost of a vapor system up nearly, if not equal, to that of hot water. However, one advantage obtains directly from these patent-

ed features, in that the companies controlling them insist on providing or approving plans and specifications where their materials are used, in order that they may safely and intelligently guarantee successful operation. This they do without additional charge; and their experience should go a great way toward insuring a properly designed heating system for a school house of small or medium size.

For large buildings an approved form of power vacuum system is recommended.

a. Direct System.

While a direct radiating steam system overcomes most of the objections to a hot air furnace equipment, in common with any direct system for securing heat, it has little advantage over the stove from a standpoint of ventilation since it affords no means within itself, of providing ventilation. With such a system the open window must be resorted to, and while some still express their convictions that the open window is the sole solution of the question of ventilation, the weight of opinion is clearly against such a practice. In not a single recent important investigation has the open window solution been proposed or supported. The logic of this present tendency must be apparent, since even the most rabid advocates of open window schools admit the need of at least a little heat in the rooms; and with open windows it is not alone a question of housing children in uniformly cold rooms, but one of subjecting them to variations of temperature that may be both sudden and extreme. This, in the opinion of those best qualified to judge, is a condition that will never be allowed to prevail for any length of time, due to the disastrous results which must follow such a course.

If it is agreed that school rooms must be continuously heated, and without any regard to the uniformity of this heat, it appears that there is little excuse for installing direct radiation and placing dependence upon open windows for ventilation, since heating with admission of cold air through windows is most difficult to accomplish and requires considerably more radiating surface than is necessary with the direct-indirect or indirect systems with natural circulation. Neglecting altogether the increased cost of operation, it appears that the first cost of the extra

radiation would be more than that of bases, dampers and diffusers for a direct-indirect system.

Of course, where windows exclusively are depended upon for ventilation the cost of vent ducts is eliminated, but this cost need be very small indeed if ducts are built directly into a new building. The installation of a direct system of radiation can be justified, if at all, only on the ground of enforced economy, and this is of doubtful accomplishment.

b. Direct-Indirect System.

The application of the direct-indirect system necessitates placing the radiators along an outside wall in order to secure the outside air supply which characterizes the system. No very definite rules have been developed regulating the size of opening and admission of air to the radiators and until recently most inlet devices were too small to admit sufficient air for ventilation of school rooms.

The principal advantages are: comparatively low first cost; a series of separate sources of heat for each room; the air is not necessarily contaminated by admission through the radiator and remains essentially as pure as its outside source; the system is not affected by winds to the same extent as the furnace system with gravity circulation, and for that reason is more efficient, more certain and more easily regulated than a furnace equipment.

With an actual opening to the outside air, such as exists for each radiator with this system, it is evident that the amount of air flowing through the opening will be dependent not only upon the difference in pressure outside and inside, created by the air inside being heated and therefore lighter, but also upon wind pressures. A strong wind blowing against the wall in which these openings are placed will cause more air to flow into the room, while a wind in the opposite direction will decrease the inflow and under exceptional conditions may even cause a temporary reversal of flow, the heated air passing from the inside outward. This state of affairs can be regulated only by judicious use of hand control.

Aside from the disturbance caused by wind which can be partially, if not wholly, remedied by regulation of dampers, the most serious difficulty with such a system arises

from the fact that in calm weather it is the heating effect of the radiator which causes air to flow into the room, the amount passing in depending upon the temperature of the radiator and increasing with that temperature. Sufficient radiating surface must be installed to heat the room in coldest weather, while still admitting sufficient air changes. Some claim that this cannot be done, but if it can, it means an extraordinary amount of radiation in mild weather, and in such weather, to prevent excessive room temperatures, use must be made of some "modulating" inlet device on the radiator to reduce its temperature or part of the radiation must be shut off, either one of which will decrease the flow of air from outside, except under favorable circumstances, and may result in too few air changes per hour. A well designed and properly installed ventilating cowl and aspirating foul air vent flue, by their activity in tending to produce a vacuum in the room, will go far toward correcting this trouble and by intelligent use of open windows, as a supplementary scheme, may result in most satisfactory ventilation in the mildest weather for which artificial heat is required.

The importance of the vent flues, in securing ventilation, readily will be seen when it is considered that air cannot continuously be drawn into a room unless air is taken out. Heating coils placed in a vertical duct heat the air, thus causing it to rise because of its lighter weight. As this heated air in rising passes directly to the roof, all the heat used in accelerating circulation is lost so far as heating is concerned. This fact renders the aspirating coil a most inefficient scheme for moving air. Where electric current is available it should be much cheaper to lead all vent flues to a motor driven exhaust fan, located just under the roof.

In years past there has been some doubt as to the ability of this system to provide proper moisture for the air after being heated, but recently there has been developed a number of "moisteners" for attachment to the radiators or to the diffusers which are now universally provided to effectually prevent draughts.

The initial cost of the average direct-indirect steam system will probably be more than that of any of the systems previously discussed, but for almost any class of school buildings

it should prove more satisfactory than any of them. Such systems are comparatively safe, economical and durable.

c. Indirect System.

(1.) Natural Air Circulation.

This system operates on the same principle as the direct-indirect, and differs in construction only in that the radiators, which are of a special type developed for this use, are placed outside, usually beneath the room, and the cold air from outside is led through ducts to the radiating surface and then rises to the rooms through other flues or ducts. Perhaps its only important advantage over the direct-indirect is that the heated air can be admitted to the rooms at any desired height above the floor or from any wall or floor surface. The additional ducts required make the expense of installation considerably higher than that of the direct-indirect.

(2.) Forced Circulation.

Indirect heating systems with forced circulation are variously known as hot blast heating, plenum, fan blast, fan coil or mechanical warm air systems. These are but different names for what is essentially the same thing and in them all we find a blower or fan added to the usual complement of equipment in an indirect gravity system. Whatever advantages may be ascribed to the systems previously described (the fan-furnace possibly excepted), all are deficient in supplying the positive ventilation assured where the blower is added. No system of natural circulation can give absolute assurance of adequate ventilation in an auditorium or in any room occupied by a large number of people.

Many devices in the way of attachments and auxiliaries have been developed to perfect the results obtained with this system. These auxiliaries include air washers, humidifiers, cooling coils, and automatic thermostatic and humidity control equipment. Where proper air washers or purifiers are operated in connection with this system, it has been found possible to recirculate air from the building, rather than take it from outside, and still obtain perfectly satisfactory ventilation. The quality of this recirculated and washed air is superior to that often obtained from outside

where dust and dirt may abound in the source of supply, as in the case where the inlet is taken from a crowded city street. The practice of recirculation will frequently reduce the cost of coal from 30 to 50 per cent., but where the source of supply is outside, the cost of fuel must necessarily be high. Electric power for driving the blower is desirable, but a low pressure steam engine operating from the system's own boiler may be employed. Wherever basement rooms are used as school rooms, some form of fan circulation is necessary, if ventilation is to be positively secured, and in such buildings, of medium or large size, it is recommended that a fan coil system be installed where the original cost and operating cost are not prohibitive.

As sometimes designed, the use of automatic temperature control devices makes closed windows a necessity since the opening of windows in one room and the attendent drop in temperature will produce overheating in another room, and while a real source of trouble in some buildings, it is evidence of a defect in design rather than in principle. The regulation of humidity, where humidifiers are used, is a matter which must receive almost continuous intelligent attention. Thermostats likewise require frequent expert attention, if they are to be kept in working order.

A modern blower type air heating and ventilating plant is composed of a number of highly developed mechanical devices, producing a complicated assembly, the various units of which are certain to break down unless given the most intelligent supervision. Many of the complaints concerning automatic or semi-automatic plenum systems, no doubt, must be ascribed to mechanical defects, sometimes of design or installation, but more often of operation and upkeep. These latter require more expert and constant supervision than is usually provided, with the inevitable result that the system breaks down sooner or later, developing many distinctly objectionable features.

Thus, the real source of trouble with the forced circulation system of heating and ventilation arises through ignorance and lack of instruction of caretakers and teachers. With co-operation between teachers and plant operators, and intelligent supervision, this system must eventually prove superior to all others, but its installation is useless, and can-

not be recommended, unless the school authorities are willing to pay a price for attendance commensurate with the high quality and first cost of equipment and the excellent results attending its skillful operation.

(3.) Combination or Split System.

The forced ventilating and heating system is sometimes varied by heating the rooms with direct radiation and supplying ventilating air at room temperature with a fan and tempering coils. This arrangement results in fuel economy to the extent that only the air furnished for ventilation need be heated. At times, when no ventilation is necessary, the fans and fan-coils may be shut down. Such a system will prove more expensive to install but is very generally regarded as an improvement over the full plenum system.

III. The Law.

In analyzing the provisions of law, those provisions which, by their own specific statement, apply to but one type of heating, and those which unquestionably can be met by every form of heating, are omitted as having no bearing on the present questions. Neither is any attention given to those regulations which apply only to systems for use in old or temporary buildings.

A. Provisions of the Law.

1. Statute Law.

   a. Fresh air shall be taken from outside the building.
   b. Fresh air taken from outside shall be properly diffused without draughts through each school room during school session.
   c. Each school room shall be supplied with foul air flues.
   d. Foul air flues supplied shall be of ample size to withdraw the foul air from each room at a minimum rate of 1800 cubic feet per hour for each 225 cubic feet of said school room space, regardless of outside atmospheric conditions.

   e. Heaters of all kinds shall be capable of maintaining a temperature of 70 degrees Fahr. in all school rooms, halls, office rooms, laboratories and manual training rooms in all kinds of weather.
   f. Heaters of all kinds shall be capable of maintaining a relative humidity of not less than 40 per cent.

B. Comparative Compliance With the Law.

In the following table, showing the relative capability of the various systems to meet the requirements, the numbers in the first column of the table refer to the provisions of the law given above under the same number. The indications of the letters are as follows:

A. Full compliance.
B. Fair compliance.
C. Poor compliance.
D. Failure to comply.

The analysis is purely arbitrary and is based on the performance to be expected, with reasonable care, in normal operation in all kinds of weather.

NOTE: In systems where the fresh air taken from the outside serves the double purpose of ventilating and heat-carrying medium, the provision requiring *proper diffusion without draughts* is interpreted, in the following tabulation, to include distribution of heat in room.

Relative Capability of System to Meet Requirements.

Provisions	Direct Systems		Direct-Indirect Systems		Indirect System Natural Circulation		Indirect System Forced Circulation	
Law	Stoves	Radiators	Heater	Radiator	Furnace	Radiator	Furnace	Coil
1	C	C	B	B	B	B	A	A
2	D	D	C	B	C	B	B−	A
3	A	A	A	A	A	A	A	A
4	C+	C+	A	A	A	A	A	A
5	A	A	A	A	A	A	A	A
6	C	C−	B	B	B	B	B	A

The short-comings of the two direct systems are considered so great as not to warrant their serious consideration. A study of the various columns will indicate an increasing qualification from left to right. The requirements emphasized by the law are such as to permit a better showing by the direct-indirect heater and the furnaces than would actually be found in practice. No requirements are made for many of the points of operation in which these devices are most faulty. In so far as the provision of the statutes are concerned the direct-indirect radiator system is just as satisfactory as the indirect radiator system with gravity circulation. The fan-furnace equipment complies only fairly with the second and sixth provisions of the law.

IV. The Demand.

A. Proven Requirements.

Practical experience and experimental research in school house heating have reduced the logical requirements to four almost universal necessities; heat, ventilation, reasonable cost, and safety of buildings and occupants.

Of these four, heat is given the position of first importance because a primal necessity. Perhaps reasonable cost should rank next, since the dictates of good business judgment and the compulsion of the law most frequently make the item of cost the determining factor in the selection of a heating and ventilating system, but because of the intimate relationship between heat and ventilation, in the demand and means of securing the same, ventilation will be considered before cost. That the equipment of school buildings should be safe is so apparent as to need no comment.

1. Heat.

Heat is an established physical necessity. There is wide difference of opinion as to the actual requirements in ventilation, or what special arrangement, if any, should be made to secure it, but no one doubts that some means of maintaining the body temperature is indispensable. However, in the supply of heat, capacity alone does not furnish all that is to be desired. Aside from the waste in heat energy, excessive temperature is the one factor in ventilation upon which all are agreed as being detrimental; and if this high temperature

is associated with a high relative humidity the result is especially injurious. During the time that artificial heat is required and throughout the hours of occupancy the temperature should be uniform within each room and constantly maintained within the ranges of the following minimum requirement schedule, recommended by the American Society of Heating and Ventilating Engineers.

Class, study, lecture and recitation rooms,	66° to 67° F.
Auditoriums and assembly rooms,	64° to 68° F.
General labratories, domestic science, and manual training rooms,	62° to 68° F.
Gymnasiums,	55° to 65° F.
Offices, reception rooms, teachers' rooms, and and retiring rooms,	65° to 70° F.
Corridors,	60° to 70° F.
Play rooms, lunch rooms, locker rooms, wash rooms, dressing rooms and coat rooms,	60° to 68° F.
Toilet rooms,	55° to 68° F.
For rooms not named, and according to use,	60° to 70° F.

A sufficient number of large, accurate, easily read thermometers should be placed in each room to enable the teacher at all times to determine the actual degree of uniformity in temperature throughout the room.

Any source of heat which does not contaminate the air or conflict with the regulations of the Health, Fire, Building or Electrical Public Authorities should be permitted to supply heat loss from the building through radiation, convection, conduction or the processes of ventilation.

Temperature regulation by hand, or automatic control, should be provided to act separately for each room and its operation should interfere in no way to decrease the volume of air required for ventilation.

2. Ventilation.

The correction of too low a room temperature is the problem of heating, and without developing the reasoning, the conclusion is justifiable that the correction of conditions above this critical temperature is the primary problem of ventilation. On every hand there is a demand for "fresh air," and to a great extent in the professional, as well as the popular

mind, this has come to mean outdoor air, but the best authorities agree that untreated "outdoor air," especially under city conditions, is seldom fresh air or even clean air. Temperature and humidity have little to do with the common conception of fresh air, but at present there is almost a unanimity of scientific opinion that these, and other physical conditions, and foreign bodies such as bacteria and dust particles, rather than any chemical constituents of the atmosphere, are of the most importance. As previously mentioned, the one principle of ventilation upon which experts are agreed is that high temperatures are destructive to health and mental vigor, and "fresh air" may best be regarded as clean air in gentle, almost imperceptible motion, and to further assure maximum comfort and render this air best suited for breathing it must have proper humidity as well as proper temperature, cleanliness and movement.

a. Temperature.

As a requirement of ventilation, entirely aside from heating, there should be a temperature range limitation.

b. Cleanliness.

Fundamentally, the air supply for ventilation should be free from dust, bacteria and other contaminations. The elimination of dust from the air supply, by means of air filters or air washers, is always desirable and may be absolutely imperative under some conditions of especially unclean air supply.

c. Movement.

A proper movement of air in contact with the body to assist in its normal dissipation of heat and prevent stagnation can best be insured by a minimum allotment of floor and air space to each person and a quantitative minimum air supply requirement per occupant, provided also that thoroughly uniform distribution be accomplished without drafts. Anemometer and carbon dioxide tests represent the best simple, practicable means available for determining the quantity and quality of air supply and its distribution. Where a gravity system of air circulation is installed, the proportioning of radiating surface and air ducts should be

such as to secure full compliance with the ventilating requirements with a temperature difference of 40 degrees F. between the outside air and that entering the room at a warm air inlet, with a room temperature of 70 degrees F.

Special provision should be made for the ventilation of cellars, toilet rooms, locker rooms, and all special service rooms. Suction or exhaust ventilating devices should be provided in all laboratories or other rooms where gases, fumes and other impurities or injurious substances are liable to contaminate the air.

d. Humidity.

On calm, sultry days in summer, the disagreeable sensations experienced are similar in quality, if not in degree, to those experienced in any poorly ventilated room. Air stagnation forms an atmospheric covering about our bodies which affects their heat conditions, and that the discomfiture outdoors in summer is less is probably due to the fact that even the most stagnant, humid atmosphere out of doors is stirred by some slight breeze. However, it must be admitted that excessively humid air, especially if accompanied by high temperature is extremely uncomfortable, and for that reason, if no other, is to be avoided. On the other hand, a very dry atmosphere abstracts moisture from the body as well as from the mucous membranes of the nose, mouth, throat, and air passages of those occupying the room. To keep the body warm under these conditions of excessive dryness the air must be hotter than it otherwise should be, the skin becomes flushed and other symptoms of ill-ventilation are developed.

The positive regulation of humidity is a most difficult undertaking under any conditions, but these difficulties can be greatly reduced, where an air washer is used, by the simple expedient of partial recirculation. With such operation, since all air is not discharged from the building, moisture is retained, and a great rise in temperature not being required, the humidy will not undergo extreme variations and can be prevented from increasing materially by varying the supply of outside air. While many experimenters are prepared to defend the practice of complete recirculation, such a step is considered too novel and radical for adoption in school build-

ings, and recirculation is not insistently recommended even as an assistance in securing humidity control.

Wherever possible the relative humidity should be controlled between the limits of 35 to 50 per cent.

3. Cost.

a. Initial and Maintenance Costs.

Reasonable cost may be defined as an expenditure comparable with the cost of other component parts of the building and its equipment, and should be in proportion to the demands and financial ability of the school community. It is manifestly unreasonable and unwise to expect the school authorities in a given case to expend large sums of money in the installation of elaborate and complicated heating equipment for comparatively small and inexpensive buildings which, within themselves as "school buildings," meet every requirement of the community.

Neither can the all too frequent present practice of installing cheap and untrustworthy apparatus of inferior design and workmanship, in an honest or alleged effort to comply with the letter of the law, be commended. Such a practice not only leads to high operating expenses, frequent repair bills, interruption in service and generally unsatisfactory results, but through these and other factors, in all probability, will effect actual harm and injury to school children in the very things which all regulating measures try to correct. The experience of others in the maintenance and repairs of any system should be sought before it is installed.

While seldom of any great consequence, in rare cases, the amount of space occupied by heating equipment, which might well be used for other purposes, may be a determining factor in selecting a system and may well be included under initial and maintenance costs.

b. Operating Cost.

(1.) Fuel.

Operating costs can be broadly classed as fuel, power and labor. Much will depend upon the design of the equipment but with equally well proportioned apparatus, and like tem-

perature conditions, the fuel cost will increase with the percentage of outside air admitted for ventilating purposes. Other things being equal, the more direct the contact of the cold air with the heating surface and the higher its velocity, consistent with the prevention of drafts, the greater the fuel economy. Thus a direct-indirect system should require less fuel than will be required where reliance is placed entirely upon open windows, thereby partially, if not wholly, making up for the difference in first cost. In general, a forced air circulating system should prove more economical than other indirect methods, and although direct radiation without ventilation will cost the least possible amount for fuel, it is attended with a probable increase in physicians' fees for the pupils.

(2.) Power.

Power, considered apart from fuel cost for heating, may be high or low in cost and easy or difficult to obtain, according to location of school and type of system installed. Where electric current is available an electric motor, owing to its ease of operation, presents the best solution of the power problem, and simplifies the problem of janitor service. A low pressure steam engine in connection with a steam system represents the next best practice and should be resorted to if electric current is not to be had and a forced ventilation system is still desirable. The cost of operation with a steam engine is particularly low since the exhaust from the engine is available as a heating medium. This economy is, of course, not secured with a gasoline engine. In fact, little can be said in favor of the gasoline engine except its low first cost, and its disadvantages can best be explained by those who have attempted to use the method.

While the installation of a power driven plant must necessarily call for a greater investment, it is not an uncommon experience to find that the saving in fuel for heating, over that of the open window method, is sufficient to largely counteract the interest and depreciation on higher first cost.

(3.) Labor.

Too much cannot be said in favor of employing care-takers, janitors, engineers and firemen who are intelligent, skill-

ful and competent in the performance of their duties. These men for all classes of school buildings should be selected on account of their special fitness for their positions, should be thoroughly instructed in their duties, and should be given pay commensurate with their responsibilities and ability. There can be no greater mistake than to permit the abuse of valuable public property through the employment of incompetent and irresponsible caretakers, just because such persons may be had for low wages. Where complicated mechanical heating, ventilating and air conditioning apparatus is installed, with or without automatic thermostatic regulation, an engineer, sufficiently expert to operate and keep in repair these devices, should be employed.

4. Safety.

If competent caretakers for the equipment of school buildings *should* be provided as a proper precaution against loss by rapid deterioration, it will be recognized as of equal importance that every provision be made against loss by fire, or other cause, in the selection of heating equipment. Admitting that the actual financial loss of purely physical property could be covered by insurance, the interruption to school service might be serious, and no one could offer any defense of a scheme which might jeopardize the lives of school children, even though it should show a lower cost, in dollars.

B. Classification of Systems According to Type of Building.

The following classification of buildings is entirely arbitrary and may be questionable in detail, but, in general, the adaptability of the several systems is as indicated. In every case where more than one system is mentioned for a given type of building the systems are listed in the order of their fitness, the most desirable being placed first.

1. Single-room building, no basement.
   (a) Direct-Indirect heater installed in room.
2. Single-room building, with basement.
   (a) Direct-Indirect single pipe steam system.
3. Two-room building, no basement.
   (a) Direct-Indirect heater installed in each room.

4. Two-room building, with small basement.
   (a) Direct-Indirect single pipe steam system.
5. Three room building, with small basement.
   (a) Indirect, gravity air circulating, one pipe steam system.
   (b) Direct-Indirect, one pipe steam system.
6. Four-room building, two floors, with small basement.
   (a) Direct-Indirect, vapor steam system.
   (b) Fan-furnace system (where electric power is available).
7. Four-room building, two floors, with basement rooms used for school purposes but not for class rooms.
   (a) Direct-Indirect, vapor steam system, on first and second floors; direct system in basement with aspirating vent flues and cowl ventilators.
   (b) Fan-furnace system (where electric power is available).
8. Six-room building, with basement rooms used for laboratory or other school purposes.
   (a) Fan-coil system (with electric power or low pressure steam engine).
   (b) Direct-Indirect, vapor system on first and second floors; direct system in basement with aspirating vent flues and cowl ventilators.
   (c) Fan-furnace system (where electric power is available).
9. Eight-room building, with basement school rooms.
   (a) Fan-coil system. Toilets ventilated by motor driven suction fan.
   (b) Direct-Indirect, vapor or vacuum system.
   (c) Fan-furnace system (where electric power is available).
10. Moderately large buildings, with basement school rooms.
   (a) Heating by direct radiation, ventilation by fan-coil system, toilets ventilated by motor driven suction fan. Air conditioning apparatus.
   (b) Heating by direct radiation, ventilation by fan-coil system, toilets ventilated by motor driven suction fan.
   (c) Fan-coil system, toilets ventilated by motor driven suction fan.

11. Large buildings, with basement school rooms.

(a.) Heat by direct radiation, ventilation by fan-coil system, automatic temperature control, air conditioning apparatus, ventilation of toilets and service rooms by suction fans.

(b.) Heat by direct radiation, ventilation by fan-coil system, air conditioning apparatus, toilets ventilated by suction fans.

(c.) Fan-coil system, air conditioning apparatus, toilets ventilated by suction fans.

In all cases, for all floors when no specific provision is made above, it is understood that aspirating vent flues and ventilating cowls will be installed.

Where not specifically provided for above, it is understood that special provision will be made to ventilate toilets, by some suction exhaust device.

In so far as possible, wherever twenty or more people are kept continuously in one room for more than one hour, or 100 people for as much as one hour, it is recommended that forced ventilation be provided. Such installation can be made to adequately care for all auditoriums and large lecture or class rooms.

V. Conclusions.

1. While the law requires a heating capacity sufficient to maintain an indoor temperature of 70° F. in all kinds of weather, it does not specify any maximum temperature limits; and this condition exists in spite of the fact that the injurious effects of overheating constitute the only undebated issue regarding ventilation.

2. No provision is made as to the point, or number of points, at which room temperature shall be observed during school hours. Thus, no specific plan is laid down for ascertaining that the temperatures are proper and uniform throughout the room.

3. It is compulsory that air be taken from outside, but no provision is made against the use of air containing excessive dust particles or other impurities.

4. While carbon dioxide in the air in quantities likely to occur in a school room, cannot be considered injurious to health, its presence in occupied rooms is regarded as an

accurate measure of the air supply and distribution in such rooms. For this reason it is recommended by no less authority than the American Society of Heating and Ventilating Engineers that a carbon dioxide test of proper supply and distribution be applied; yet, no such provision is made by the law.

5. While the excellent qualities of the fan-coil system are recognized, it is readily admitted that conditions are not such as to warrant its use in all cases. Many times its cost renders it entirely prohibitive. In such cases the direct-indirect system offers the best substitute, considering both cost and results, since this system yields results practically equal to those obtained with the gravity indirect and, in general, possesses more commendable features than any other, excepting only the fan-coil system.

6. Evidence is lacking to show that as a permanent equipment for school house heating and ventilating, a well designed and constructed system of a theoretically poorer type will render better satisfaction than a poorly constructed, cheap system of a theoretically better type. Furthermore, a mediocre type of apparatus, when given careful, intelligent attention, will yield more satisfactory results than can be attained with the finest system in the hands of an ignorant and inexperienced operator.

7. Finally, selection of all equipment and attendants should be made with the idea of safeguarding the expenditure of public money and the loss of property, and, more especially, the health and lives of school children.

* * *

We submitted Professor Veal's report to the professors of mechanical engineering of the universities of the states of Ohio, Illinois, Michigan, Kentucky, Nebraska and Minnesota, also Purdue and Rose Polytechnic Institute, and received the following replies:

"Lafayette, Ind., October 17, 1916.

Mr. Gilbert H. Hendren,
State Board of Accounts,
Indianapolis, Indiana.

Dear Sir:—

I beg to ackowledge the receipt of a copy of Professor Veal's report to the State Board of Accounts accompanied by your explanatory letter of

October 13th. I wish to commend unqualifiedly the action of the Board of Accounts in taking up this subject.

Any one who has had to do with public business is soon made to realize the pressure brought to bear by those who wish to sell their apparatus or supplies regardless of their appropriateness or usefulness. Where public servants lack the technical information necessary to their guidance in meeting these questions, it is absolutely necessary that the disinterested and impartial guidance of technical experts be brought in.

This you have well accomplished in asking Professor Veal to investigate and report on the question of school house heating and ventilation. His report will be found a valuable guide to those concerned with school house construction. I trust that it may be found possible to carry out the finding of his report, being convinced that in so doing public funds will be conserved and the health and comfort of the school children ensured.

Very truly yours,
W. E. Stone,
President.

"Lafayette, Ind., October 10, 1916.

Mr. G. H. Hendren, State Examiner,
State Board of Accounts of Indiana,
Indianapolis, Indiana.

Dear Sir:—

I have before me the report of Prof. C. B. Veal, professor of engineering design of heating and ventilating of Purdue University, made to you at my suggestion.

As head of the school of mechanical engineering and as an engineer conversant with the problems that have confronted you in the matter of regulation of heating and ventilating in the school buildings of Indiana, I unhesitatingly recommend this report to you for your earliest consideration. It has never been my privilege to read a more impartial and carefully thought-out discussion of the heating and ventilating situation as applied to public buildings. It is technically accurate and trustworthy, and the statements contained therein are equally understandable to the layman and to the engineer. The scope of the report is broad enough to cover all the questions you have before you, and I heartily endorse the

same. It is a double pleasure, therefore, on my part to recommend to you this report as the work of one of my own highly esteemed heads in my own school with the hope that its value you will recognize the more the longer you study its contents.

Yours respectfully,
G. A. Young,
Prof. and Head of the School
of Mechanical Engineering
of Purdue University."

"Columbus, Ohio, Oct. 2, 1916.

Mr. Gilbert H. Hendren, State Examiner,
State Board of Accounts of Indiana,
Indianapolis, Indiana.

Dear Sir:—

Agreeable to your request we have carefully read a copy of the report to you of Prof. C. B. Veal, of Purdue University, on School House Heating and Ventilating Regulations in Indiana, together with the Indiana Law on the subject.

We desire to commend the above report as being comprehensive, thorough, complete, and accurate in its statements of engineering facts and opinions and highly commendable for practical use by persons interested in the subject.

* * *

Respectfully submitted,
Wm. T. Magruder, Prof.
Mech. Eng.
F. W. Marquis, Prof.
Steam Eng., Ohio
University."

"Urbana, Illinois, Oct. 6, 1916.

Mr. Gilbert H. Hendren, State Examiner,
State Board of Accounts of Indiana,
Indianapolis, Indiana.

Dear Sir:—

At your request the writer has read a report on 'School House Heating and Ventilation Regulations in Indiana,' prepared by Prof. C. B. Veal.

This report is a very complete analysis of methods of school house heating and ventilation, and its recommendations as to the best practice in this field of work are, in general, admirable. The writer approves of Prof. Veal's attempt to specify what he considers the best or ideal system of heating and

ventilating each class of school buildings, but believes that somewhat more latitude should be permitted in the 'approved' systems for the smaller buildings. Due consideration must be given to the cost of installation and operation of such systems in very small buildings, or the regulation requirements will prove practically prohibitive in many cases.

* * *

Very truly yours,
A. C. Willard,
Assistant Professor,
Heating and Ventilation, Illinois State University."

"Lincoln, Nebraska, Sept. 5, 1916

Mr. G. H. Hendren, State Examiner,
State Board of Accounts,
Indianapolis, Indiana.

Dear Sir:—

Prof. Veal's report is a logical and clean-cut analysis of the subject.

* * *

Very truly yours,
J. D. Hoffman, Prof. Mech. Engineering and Practical Mechanics, University of Nebraska."

"Ann Arbor, Mich., Sept. 12, 1916.

Mr. G .H. Hendren, State Examiner,
Indianapolis, Indiana.

Dear Sir:—

I have examined the report carefully and it meets with my approval. I feel that your committee has done well in being fair to all the different types of heating systems that might be used for the purpose covered by this report. It has my unqualified approval.

Yours, very truly,
John R. Allen, Prof. Mech. Engin., University of Michigan."

"Minneapolis, Minn., Sept. 28, 1916.

Mr. Gilbert H. Hendren, State Examiner,
Indianapolis, Indiana.

Dear Sir:—

I have spent considerable time at various intervals in reading carefully the report on 'School House Heating and Ventilation in Indiana', by Prof. C. B. Veal of the engineering department of Purdue University. The report is a distinct contribution to the subject of school house heating and ventilation.

* * *

Yours, very truly,
S. A. Challman, Commissioner of School Buildings, University of Minnesota."

St. Paul, Minn., Oct. 9, 1916.

G. H. Hendren, State Examiner,
State Board of Accounts,
Indianapolis, Indiana.

Dear Sir:—

I have been thru the report of Prof. C. B. Veal covering school house heating and ventilating regulations in your state. I find his classification to be clear and concise. I find his descriptions of the systems also beyond criticism. His comments as offered on the several systems are well worth the consideration of those in authority.

* * *

The conclusions as they appear in the report, nine in number, I can subscribe to with comment directed to number 8. This I will not criticise, but will make more emphatic my approval of the points contained in this article. As a whole, therefore, I place my approval upon the report. The comments which I have named are made in the light of a colder climate than exists in the region of Indiana. Prof. Veal is deserving of much credit for the complete handling of the subject.

Yours truly,
J. L. Mowry, Prof. Agr. Eng.
University of Minnesota."

"Terre Haute, Ind., Oct. 6, 1916.

Mr. G. H. Hendren, State Examiner,
State Board of Accounts of Indiana,
Indianapolis, Indiana.

Dear Sir:—

I have read carefully the report submitted to you by Prof. C. B. Veal upon school house heating and ventilating regulations in Indiana, and I agree in all substantial particulars with the views expressed in that report.

* * *

I am also in hearty accord with the opinion ex-

pressed by Prof. Veal to the effect that the kind of heating system used should correspond with the type and size of school building to which it is applied. The suggestions contained in the report along this line seem to me to be well worth the careful consideration of those intrusted with the authority of selecting heating apparatus for schools.

Yours, very truly,
Frank C. Wagner, Prof. of Mechanical and Electrical Engineering, Rose Polytechnic Institute."

"UNIVERSITY OF KENTUCKY

Lexington, October 26, 1916.

Mr. G. H. Hendren, State Examiner,
State Board of Accounts,
Indianapolis, Indiana.

My dear Sir:—

Acknowledging your telegram of even date, I confirm telegram as follows that I have just sent to you:

'Report received. I regard the report of Prof. C. B. Veal as a masterly discussion of school house heating and ventilating practice as particularly applicable to Indiana requirements.'

I want to congratulate you upon the way you have handled the question of school house heating and ventilating in Indiana. When you put a problem of this kind in the hands of scientific men you eliminate to a large degree the possibility of irrational conclusions that are almost certain to arise when the whole question of letting contracts is thrown open to contractors who are allowed to put in bids on any sort of apparatus, sometimes for the express purpose of confusing committees.

Yours, very truly,
F. Paul Anderson,
Dean."

In my judgment, Prof. Veal and Purdue University are to be congratulated for this valuable contribution that will inure to the public good. I believe the impartial conclusions reached will, in a great measure, solve the perplexing problem of proper heating and ventilation of public buildings and

result in the elimination of dishonest practices in contracts of this class.

Respectfully submitted,
Gilbert H. Hendren,
State Examiner.

January 15, 1917.

Rules of the State Board of Accounts Concerning Public Building Contracts.

It is the purpose of the State Board of Accounts to prepare rules and regulations relating to public contracts governing public work that will conserve the public funds of the various municipalities of Indiana. Such rules are intended to prescribe the method of awarding contracts, the preparation of plans and specifications for such work and the supervision or superintendency of the work to the end that there shall be unrestricted competition and honest methods employed in this work.

These rules are made with the hope of assisting officers of the counties, townships, towns and cities of the state in getting greater competition in the letting of contracts for the erection of buildings, furnishing heating, ventilation, plumbing, electrical fixtures, supplies of all kinds, and in any undertaking where competitive bids are to be received and the expense is to be paid from the public funds, to the end that fair prices may be obtained in all cases.

It is the duty of the State Board of Accounts to determine whether the laws of the state are complied with in the letting and carrying out of each public contract, as well as to prescribe the methods of accounting, and to determine the accuracy of the accounts in connection therewith.

Public officials before contracting for the construction of of any important public work to be let upon competitive bids should employ a competent architect to prepare plans and specifications for the same. The plans and specifications so prepared should be complete in every detail and so perfect in detail that the work will comply with the law in regard to same, and so that no material change need be made in the

construction of said work from the original plans and specifications therefor. Any material change made in the construction of any public work after the bid therefor is accepted and the contract entered into, tends to destroy competitive bidding and is a violation of the spirit of the law.

Where heating and ventilating systems are to be installed in old public buildings, professional heating and ventilating engineers should be employed to prepare plans and specifications, or if an architect is employed to do such work, he should also be properly qualified as a heating and ventilating engineer. In no event should anyone be employed who is in any way connected with any dealer or manufacturer who may be furnishing the material for such particular heating and ventilating system. The name of the engineer who lays out the heating and ventilating system should appear upon the plans and specifications in connection with all heating and ventilating installations.

It is not our purpose to encroach upon any official's duty, but to help officials to comply with the law, to keep their accounts accurately and to assist them and the taxpayers of the different municipalities in obtaining value received for the money expended.

In all cases where contracts are to be let by competitive bidding, it is unlawful to adopt plans and specifications for heating and ventilating systems, water systems, vacuum cleaning systems, closets, furnaces, fans, motors, and engines, or other manufactured articles, which require the furnishing of articles exclusively under the control of one person, firm or corporation.

Board vs. Pashong, 41 Ind. App. 69.
Managhan vs. City of Indianapolis, 37 Ind. App. 280.
Seibert vs. City of Indianapolis, 40 Ind. App. 296.
Zorn vs. Warren-Scharf Co. 42 Ind. App. 213.

No contract can be let when the plans and specifications for materials or fixtures to be furnished are not specific, but leave a part of the details, which should be included in the plans and specifications, to be furnished by the bidders themselves. No bidder shall be allowed to furnish his own plans and specifications, but all bidders must bid on the articles, systems, etc., adopted and included in the approved plans and specifications. The purchasing of furniture and supplies

and the erection of public buildings are matters which concern, in a more or less degree, every taxpayer in the municipality. These matters are strictly public undertakings, and, as such, taxpayers are entitled to have the law strictly complied with before the burden is placed upon them. Our purpose of requiring plans and specifications is to provide a basis for competitive bidding on the proposed undertaking; without such a basis the bidders would be left to speculation and uncertainty in making bids, and the door of favoritism would be open in awarding contracts.

The Standard Contract Documents as issued by the American Institute of Architects and approved by the respective National Association of Builders' Exchanges, Master Plumbers, Master Steam and Hot Water Fitters, Sheet Metal Contractors and Electrical Contractors of the United States are, in a general way, applicable to the erection of public buildings under the laws of Indiana. But they are prepared more especially for building enterprises by private capital, as this is by far the larger part of the work of the architects. A few changes are usually desirable to make these documents conform to the requirements of the Indiana law for the reason that an individual may do what a public official cannot do. They should never provide for changes and they should never provide that the architect's decision as to workmanship and material is final and without appeal.

Architects and engineers are employed in an advisory capacity only and the public official, whose duty it is to contract for and have a building constructed or other work performed, cannot delegate the power vested in his office by law, to an architect or engineer.

An individual may select a particular kind or make of material or fixtures to be used in a building which he may desire to erect regardless of the fact that such material or fixtures may be under the exclusive control of some one person, firm or corporation, while a public official must follow the rules laid down by law and prepare his plans and specifications so as to secure competitive bids at the letting of the contracts.

A public official is acting for the taxpayers of the taxing district which he has been chosen to represent and he has no authority except what is vested in his office by law.

Brick is a manufactured article and must be specified so that there will be competition in order to comply with the law. The standard should be established by naming the brick manufactured by three or more manufacturers and providing that any other make of brick, similar in design and equal in quality, may be specified by a bidder in his bid and used, if approved by the architect and officers having charge of the construction of the building.

Manufactured articles, such as hot air furnaces, air washers, purifiers, fans, engines, motors, heat regulation, vacuum systems, closets, lavatories, drinking fountains, shower baths, urinals, vacuum cleaners, metal ceilings and lightning rods are somewhat difficult to specify without favoring some particular make. It seems that the best method of having open competition in this class of supplies is by establishing a standard, which may be done by naming at least three or more of such manufactured articles, by giving the name of the manufacturer and the catalogue number, providing that other articles similar in design and equal in quality may be specified by a bidder in his bid and used, if approved, by the architect or engineer and officers having charge of the construction of the work.

Such raw material as sheet metal may be described in the specifications by giving the quality and gauge of the articles to be used. Pipes for heating plants may be described by giving the size and quality expected to be used. Steam boilers, direct-indirect and direct radiators, valves, wall boxes, box bases, air diffusers, humidifiers and all other articles should be specified in the specifications by naming at least three or more such articles, if possible, giving the name of the manufacturer and the catalogue number which will give the type and capacity of such articles desired, providing that other articles similar in design and equal in quality may be specified by a bidder in his bid and used, if approved by the architect and officers having charge of the construction of such work. The size and location of all fresh air wall boxes, foul air flues, steam pipes, steam boilers, direct-indirect and direct radiators, hot air furnaces, warm and cold air ducts, engines, fans, motors, water closets, urinals, lavatories, drinking fountains, shower baths, vacuum cleaners, and metal ceilings should be shown on the plans and described in the specifications.

Specifications for any school building should be so worded as to make plain to the bidders that the successful bidder will be required to guarantee in his written contract that any material, supplies or sanitary apparatus or system, which are furnished, constructed, remodeled or installed in and for a school building shall be practically noiseless, free from friction and will, in all respects, comply with the provisions of the Sanitary School House Law of Indiana. If bidders do not wish to make this guarantee in the contract, they should refrain from bidding on the work to be let.

Bids for all work should be made on blank forms approved by the State Board of Accounts, Amended Form No. 10.

After advertisement has been made as required by law and bids received for the contemplated work, county commissioners, the trustee and advisory board or the board of school trustees should take plenty of time to investigate and determine who is the lowest and best bidder. Many things must be considered in determining this, among them being the ability and responsibility of the bidder as to workmanship and his conduct in the construction of buildings in the past.

Plans and specifications for any public undertaking which are approved, adopted and paid for by a municipal corporation are public records and the architect shall furnish one complete set thereof to the proper official and one to the State Board of Accounts, which shall be kept on file in each of these respective offices. These plans and specifications shall not be used for any other building or buildings. Said complete set of plans and specifications should be submitted to the State Board of Accounts for examination and approval at least five days before advertising for bids, and such approved plans and specifications may then be inspected by any prospective bidder.

One of the main objects to be accomplished from our point of view is to have the specifications so worded that manufaturers of several different materials or manufactured articles will figure with the bidders on furnishing their particular make of material or supplies and being placed in competition with other manufacturers of similar articles, will, of necessity, make their lowest price, thus giving the munici-

pality the advantage in any reduction in price caused by such competition.

Quality and quantity shall be scrutinized as in the purchase of supplies and material bought for public use. Plans and specifications shall, in fact, be a part of the contract for public work and public buildings and shall be strictly construed in favor of the public treasury. "Extras" shall be kept at "low tide," as they are without competition and nearly always expensive.

The time for completion of the contract should be expressly stated in the specifications. The limit of time in all specifications should be conservative and provide for the allowance of additional time on account of delays, over which the contractor has no control. Said specifications should provide that a sum shall be paid to the contractor during the progress of the work not exceeding eighty-five per cent. (85%) of the labor actually performed and material used in said work, upon the written estimate of the architect, and the residue of the contract price shall be paid at the expiration of thirty (30) days after the completion and final acceptance of the work, in order to protect laborers, sub-contractors and material men, as provided in the Acts of 1911, page 437. The architect or engineer should be required to furnish the official who has charge of the construction of the building, complete copies of the plans and specifications without extra cost, and supply prospective bidders with copies of the plans and specifications, upon the deposit of a reasonable amount for the return of the same before the hour set for receiving bids for such work, and upon failure so to do, such deposit will be forfeited.

We believe that every honest contractor should know and feel that the opportunity to all bidders will be free and unrestricted and that there will be no attempt in any way to prevent legitimate competitive bidding.

It would be impractical to formulate rules that would show how this purpose could be accomplished in every instance, as so many different things come up in the making of plans and specifications that the rules would be too long and cumbersome. But, with this end in view, architects and engineers, in making their plans and specifications, can so treat each individual case as to reduce possible favoritism to the minimum, thereby complying with the law.

Public officials should thoroughly understand that they cannot arbitrarily select the particular make of articles they desire to purchase for their constituents, but must, in order to comply with the law, provide for the selection of these articles by competitive bidding.

Architects or others cannot become bidders or sub-contrators on work where they have furnished plans and specifications, or where they are directly or indirectly interested in the contract.

In the construction of public buildings, it should be so arranged, if possible, that the contractor could do the construction work during the proper season and not leave partially constructed buildings standing during the winter.

The architect or engineer should ascertain the financial ability of the township or school corporation, or other municipal corporation, and prepare plans and specifications for work, an estimate of which is within the two per cent. limit of indebtedness allowed by the state constitution.

In determining the maximum amount of indebtedness that can be created by a civil or school corporation you should take two per centum of the total value of the taxable property within such corporation, to be ascertained by the last assessment for state and county taxes previous to the incurring of such indebtedness and not deducing mortgage exemptions, and add thereto such an amount to be derived from existing levies that can be applied to the payment of the indebtedness of the corporation. In other words, to the two per centum of the taxable property you can add so much from the existing levies made at the time of the creation of the indebtedness as will not be required to meet the current expenses of the corporation and which can be applied to the proposed indebtedness. In all events there must be an appropriation available for the construction of the proposed building.

We respectfully call your attention to sections 3867, 3868 and 3869, Burns's R. S., 1914, which relates to combinations in restraint of trade.

Section 3868, Burns's R. S., 1914, reads as follows:

> "Any and all schemes, designs, understandings, plans, arrangements, contracts, agreements or combinations to limit, restrain, retard, impede or restrict bidding

for the letting of any contract for private or public work, directly or indirectly, or to in any manner combine or conspire to stifle or restrict free competition for the letting of any contract for private or public work, are hereby declared illegal, and any person who shall directly or indirectly engage in any scheme, design, understanding, plan, arrangement, contract, agreement or combination to limit, restrain, retard, impede or restrict bidding for the letting of any contract for private or public work, or in any manner combine or conspire to stifle or restrict free competition for the letting of any contract for private or public work shall be deemed guilty of a misdemeanor, and upon conviction shall be fined in any sum not exceeding five thousand dollars, to which may be added imprisonment in the county jail or workhouse for a term of not more than one year, in the discretion of the court or jury trying the cause."

Under section 3869, Burns's R. S., 1914, it is provided that if there shall be any collusion or fraud of any kind or character among the bidders at the letting of any contract, that such contractor shall not be entitled to payment for any work done thereon if he were a party, either directly or indirectly, to the fraud. This department will use its best efforts to prevent any payment to a contractor for work or services performed by him if it should be able to establish that such contractor was a party to such fraud.

You will note by the foregoing that the sole object of the State Board of Accounts is, through its supervision of public offices, to secure an administration of public affairs that will at all times be in the interests of the taxpayers. We believe the laws are ample to protect the public and, as applied to contracts for public work, will give every honest person a square deal. We invite the co-operation of honest and capable architects, contractors, manufacturers of supplies and in fact all citizens in our endeavor to secure these results.

These rules were submitted to and approved by the Attorney General, February 16, 1916.

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END OF
TITLE